tions of the epithelium prevent, save in rare instances, their recurrence there.

Before concluding this brief summary, the earlier investigations of Hönigschmied, Hoffmann and Lustig should be mentioned. Hönigschmied, in a communication on the microscopic anatomy of the taste-organs (*Zeit. f. wiss. Zool.*, xxiii, 1873), merely remarks that he failed to detect in the circumvallate papillæ of the new-born child any regular arrangement of the bulbs. Hoffmann (*Virchow's Archiv*, lxii, 1875) investigated the human embryo and new-born child for the purpose of studying the distribution of the taste-organs in man. In a fungiform papilla of a four and one half months' fœtus, and also in the papillæ of one at the sixth month, he found taste-bulbs, but he failed to detect them in earlier embryos. He concludes that they are more frequent in embryos and in newly-born than in older individuals; that in embryos and new-born children they occur more frequently and in greater number on the free surface of the papillæ than in the adult, and that in old persons they are but rarely met with in this region. Lustig (*Sitzb. d. k. Akad. d. Wiss. Wien*, lxxxix, iii, 1884) failed to detect bulbs in the papillæ of a fœtus at the end of the fifth month, but in one at the seventh he found them on the free upper surface of both circumvallate and foliate papillæ. While taste-bulbs were wanting in the tongue of a ten weeks' embryo, it is not improbable that they may yet be found in the incipient stages of growth in one of the twelfth week of intra-uterine life.

F. TUCKERMAN.

II.—EXPERIMENTAL.

Ueber die Theorie des simultanen Contrastes von Helmholtz. E. HERING. Four papers in Pflüger's Archiv, Vols. 40, 41, 43.

I. *Die farbigen Schatten.* Helmholtz considers that the experiments with colored shadows show conclusively the influence of the judgment in producing simultaneous contrast. Hering, by more careful experiments, makes it plain that this is not the case. He makes the usual arrangement for colored shadows, the sources of light being day-light and a gas-flame, and the tube being arranged so that it can be instantaneously split open. The tube is so directed that the observer looks half upon the gas-lighted paper and half upon the blue shadow, complete fixation being made easy by a dot in the middle of the line of separation. To facilitate reference we shall call the shadow half of this field *s*, and the gas-lighted half we shall call *g*. After everything is in position, the gas is lighted, and *s* instantly becomes blue and *g* yellow, the yellow being an objective color and the blue subjective. Whether that subjective blue is physiological (in the retina) or psychological (in the judgment) is the question at issue.

The next step in the experiment is to move the shadow-throwing prism so that the tube looks wholly upon its shadow. Under these circumstances, according to Helmholtz, the whole field of the tube is blue, and this shows that the effect is due to the judgment; what one has just judged to be blue one still judges to be blue, and other reason for seeing this blue there is none. But as matter of fact, if the fixation has been careful, *it is not true* that the whole field of the tube is now blue; on the contrary, *g* is blue, but *s* is a distinct grayish-yellow. The blueness of *g* is now easily accounted for,—it is simply the complementary fatigue-color to the former yellow gas-light. Hence there is no occasion to say anything about the persistence of the judgment-error. But what is the cause of the yellowness of *s*? If the former blueness of *s* was physiological—a spreading over of the yellow-excitation, as Hering believes—then it, too, is due to fatigue. But it is still possible

at this stage, as it seems to the reviewer, that the color of *s*, both in the first and in the second phase of the experiment should be due to judgment contrast.

There is a third phase to the experiment, however; the gas is extinguished and the tube is suddenly opened. Helmholtz says that everything now appears of a natural white. But in fact, if one looks carefully, one can still see a circular spot, the field of the tube, the colors of both *s* and *g* being very much the same as in the second phase. This after-image persists longer, the longer the first phase and the shorter the second phase have lasted. There is no difficulty in getting it, even without the self-opening tube. It was overlooked by Mr. Delabarre, who has repeated these experiments, and who says, "If . . one lay aside the tube and glance at the field the color at once disappears." (This *Journal*, Vol. II, p. 641).

This after-image lasts a much shorter time, of course, than that in the second phase. Its occurrence seems to the reviewer to render it certain that a mistaken judgment is at least not the principal cause of the whole phenomenon. It is incredible that a mistake should extend itself over a small semi-circular spot and no farther.

II. *Der Contrastversuch von H. Meyer und die Versuche am Farbenkreisel.* Hering first calls attention to the fact that he, too, lays great stress upon the effects of experience and of practice, as is shown in his *Gedächtniss als eine Function der organischen Materie*, and that if he does not agree with Helmholtz in explaining simultaneous contrast as an effect of the judgment it is simply because the facts seem to point, in this case to a different explanation. In order to show that simultaneous contrast is due to the judgment, Helmholtz endeavors, in all cases where the sensation is a strong one, to so vary the circumstances as to make it weak, or evanescent; for instance in Meyer's contrast-experiment he shows that if the grey ring is held in front of the colored paper so as to be plainly distinct from it in space, its color vanishes. But Hering points out that *actual* slight-differences in color are easily made to vanish by slightly varying the circumstances. A feeble after-image which one can easily see on a smooth surface will quite fade out on a rough one. A slight difference of color of two papers is overlooked if one is smooth and one rough, or even if they have a different grain, and they are so held that the grain is perceptible. A black mark around one will also destroy the difference. On a color-top, all unevennesses of surface disappear and a color is seen in its ideal state. But a bit of paper of exactly the same color as the top, when held in front of it, will look different. Even if the paper behind is not rotating, one cannot be sure that the one in front is of the same color, so long as there is a difference of brightness, or a distinct edge, and all the more if one cannot accommodate for both at once. If the lighting is as near as possible alike, and if the accommodation is for neither (so that the edge becomes indistinct) the observer may think the colors alike, but he may also actually fail to see that there are two different papers, however much he knows that there are two. Fixate a bit of paper in front of a ground of the same, but shove in between them a black card-board for a few seconds; then remove suddenly both the card-board and the bit of paper. A spot appears on the ground, which is of different color from that, and which is also perceived to be a different color from the just-removed bit. In other words, a separate bit, *seen to be such*, forms a hindrance to perceiving a slight amount of difference. But this is a case of an *after-image* being far less perceptible on the scrap of paper itself than on the large sheet; and Helmholtz himself would not say this proves the psychological nature of *after-images*. No more should a similar fact be taken, then, to prove the psycho-

logical nature of simultaneous contrast. This experiment has been varied by the reviewer by having two dots on the scrap of paper, and fixing first one, and after the black card-board is removed, the other. In this way the after-image of the scrap falls in part on the scrap itself and in part on the paper underneath, and the two colors can be compared at leisure. In this case, *no difference can be detected* in the two colors, other than what is due to some unavoidable difference of brightness. But Hering might reply that in this case, the after-image, even where it falls on the scrap, is taken to be a distinct object, and not a simple color of the scrap of paper.

These considerations remove the force from most of Helmholtz' arguments in favor of judgment as a cause of simultaneous contrast. Hering denies that the brightness of the contrast-color does not increase with the saturation of the inducing field, but his experiments in another paper (Pflüger's Archiv, XLII, p. 119. See this *Journal* I, 706) are more conclusive on this head. This point is important, because the opposite fact is considered by Wundt to be the chief objection to the whole theory of Hering (Phil. Studien, IV, p. 312.)

III. *Der Spiegel-contrastversuch.*

In the experiment of Ragona Scina, a vertical and a horizontal sheet of white paper have one edge together and a colored glass plate forms an angle of 45° with each. Instead of small black squares on the sheets of paper, Hering uses concentric black rings. One ought to see a mirrored vertical ring green (using green glass), a horizontal one white, and the space between them a mixed whitish green, but the white one is by contrast red. If the brightness of the whole is properly regulated (it is enclosed in a chest), the success of the experiment is surprising, the red is quite as saturated as the green. Helmholtz' explanation is that since we suppose the greenness of the plate to be uninterrupted, a spot which really looks to us white we fancy to have a red spot underneath it, because it would take a red spot under a green glass to *look* white. This explanation assumes an extraordinary power on the part of the observer in picking out complementary colors; it is completely vitiated by the fact that the red color is as distinct as ever when, by a proper framework, the green plate is made perfectly invisible, and to a fresh observer who is quite unaware that there is any plate there. Moreover, by moving the sheets of paper (and so making the rings not quite concentric) the green rings may be made to seem in front of the red, or the red in front of the green, at pleasure. The red and green rings seem to swim in a whity-green space like birds in a blue sky. According to Helmholtz, a bit of white paper held evidently in front of the green cloud does not look red; but according to Hering, if it is fine-grained, and if the color and brightness are exactly the same, it looks quite as red as the other, even though it be made to swing in front of the glass plate and be looked at binocularly, and this whether the glass-plate is visible or not. In this, as in every case of simultaneous contrast, the color is very fleeting if successive contrast is carefully shut off by means of fixation. It quickly passes over into what Hering calls the "simultaneous induced" color, which is the same as that of the inducing field. [This name is very bad, because it does not distinguish the thing from the simultaneously induced opposite color. There is a great need of a new terminology for contrast, to take the place of the both cumbrous and inexact one which is now in use. Helmholtz frequently uses *contrast* alone, when it is impossible to find out by the context whether he means simultaneous contrast or successive contrast. The following may be proposed. In the first place, there is no reason why we should not say *co-color* instead of *complementary color*, as we have long said *cosine* instead of *sine of the complementary angle*. We might then have for the four things to be named:

1. Induced co-color (brief, and, if there is fixation quickly passing over into)	if Hering is right.
2. Induced self-color.	
1. Judgment co-color.	if Helmholtz is right.
2. Spread self-color (Physiol. Optik, p. 400.)	
3. Positive after-images.	in both cases.
4. Negative after-images	

(1) and (2) are occurrences in the immediate vicinity of the original impression, (3) and (4) are occurrences in the same place. REV.]

IV. *Die subjective "Trennung des Lichtes in zwei complementäre Portionen."*

Helmholtz is of the opinion that our unconscious experience causes us, under certain circumstances, led by unconscious false judgment, to separate an actual white sensation into two components, and to deceive ourselves into thinking that we see one of these components only. This hypothesis is used by Helmholtz to explain many cases of color-contrast. Hering has already given reasons for not adopting it, and more follow in this article. It presupposes, for one thing, an acquired unconscious knowledge of what colors are complementary which is totally wanting in our conscious store of knowledge,—a rather violent supposition, and one which could only be accepted if colored veils and mists and glasses had been much more common in the experience of our remote ancestors than there is any reason to suppose that they have been. Helmholtz considers that it is easily possible, when an object is seen through a colored screen, to decide what part of the mixed color perceived is due to the screen and what to the object. Hering shows that when proper precautions are taken this is an absolute impossibility. An observer, provided with a tube, looks through a thin colorless glass plate and sees a transmitted image of a piece of colored paper behind the glass with a reflected image of a smaller, differently colored piece of paper from in front thrown upon the middle of that. If the front and back papers are equally distant from the glass plate, the two objects seem like one; if either is moved, one is seen to be plainly in front of the other, since they are looked at binocularly. But in either case, *the color of the combined images is the pure color of the mixture*, there is not the slightest tendency to separate it up, subjectively, into the two colors of which it is really composed, provided that all the proper precautions have been taken in preparing the experiment, although it is impossible not to perceive that one object is seen through another.

Hering promises, at the end of this communication, another, in which he will speak of general considerations having a bearing upon Helmholtz' theory of simultaneous contrast. C. L. F.

Sur la vision des couleurs de contraste. D. AXENFELD. Archives italiennes de Biologie. Vol. XI, part 1, Jan. 1889. Extract from the Bullettino della R. Accademia medica di Roma, An. XIV, 1887-88, fasc. 7.

Axenfeld gives an improvement on Ragona Scina's method of producing color-contrast. In front of a source of light he puts a screen with holes in it, and allows these holes to mirror themselves in a plate of colored glass. The images from the front and the back surface of the glass show complementary colors. For binocular color contrast, he produces double images of a black square on white paper, one eye looking through colored glass and the other not. He is of the opinion that the contrast-appearances due to light penetrating through the sclerotic coat are not produced by fatigue, since they appear instantaneously. He attributes great weight to the fact that one of the colored surfaces seems, in all these cases, to be transparent, and hence he concludes that the psychological part of the explanation cannot be entirely dispensed with. In general, he accepts Hering's color theory.